SCR Catalyst Testing
Data Validation Report

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Scope

The purpose of this report is to outline the findings from ICT's quarterly instrumentation validation testing. To ensure that only quality data is provided to our partners, ICT conducts a series of testing including:

- Spiked gas testing
- Comparison of O_2 measurements with an external gas analyzer
- EPA Method 4 for water content confirmation
- EPA CTM-027 for NH_3 concentration verification
- Velocity traverses of duct work
- Repeatability testing for deNO_x, SO_2-SO_3 oxidation, and differential pressure
- Repeatability with XRF chemical analysis
- FTIR agreement for non-reactive species (CO_2)

Spiked Gas Testing

ICT's microbench system was setup so that a gas flow mixer using mass flow controllers (MFC) and gas cylinders with certified concentrations of NO, SO_2, and NH_3 were used to generate a gas stream. Two FTIRs, one positioned at the inlet of the test chamber, and the other at the outlet, were exposed to the generated gas stream and measurements for NO, SO_2, and NH_3 were recorded. Figures 1, 2, and 3 show the comparison of the measured gas species from each FTIR compared to the "Actual" concentration of the gas species when simulated by the MFCs. All axes give the concentration of the gas species in ppmvd.

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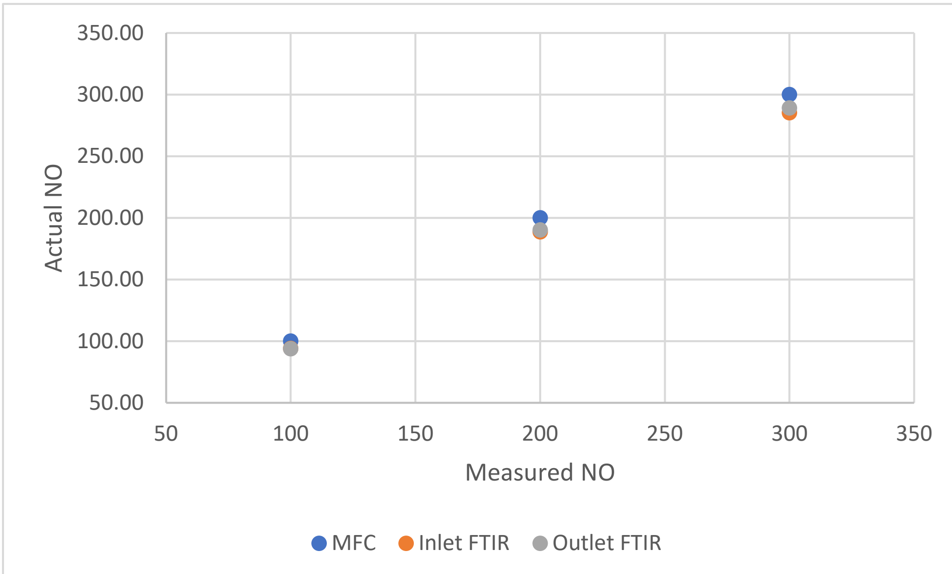

Figure 1: The FTIR measured NO versus the calculated flow mixer concentration

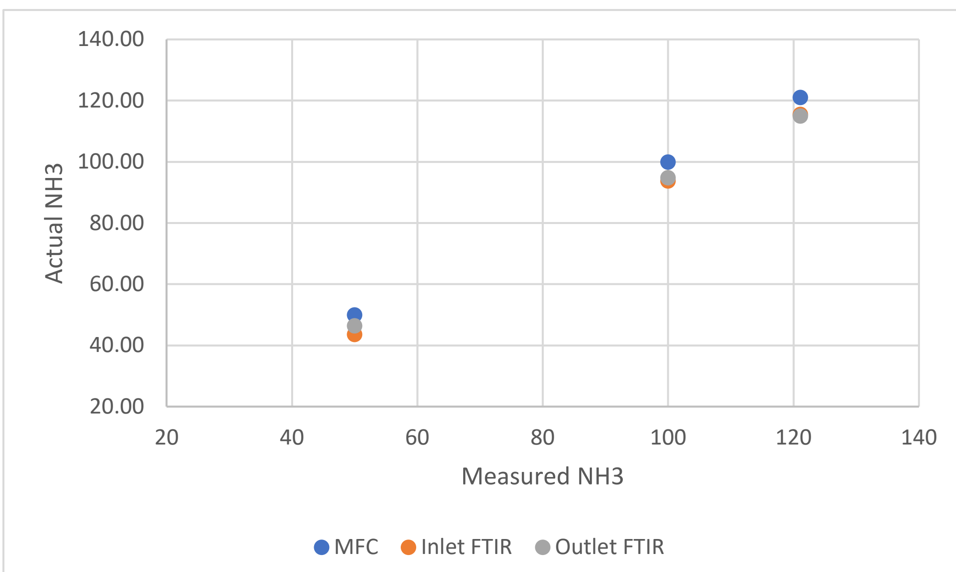

Figure 2: The FTIR measured NH_3 versus the calculated flow mixer concentration

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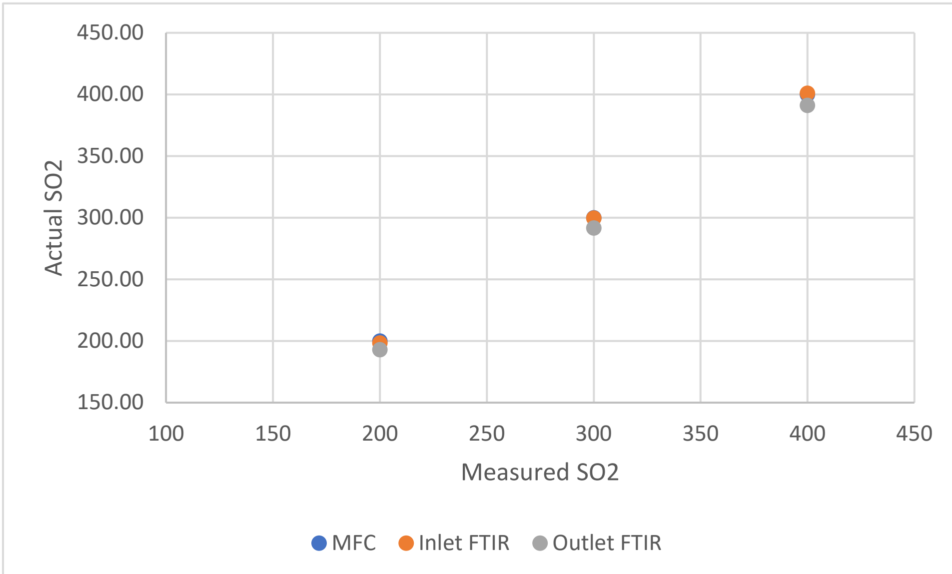

Figure 3: The FTIR measured SO_2 versus the calculated flow mixer concentration

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Comparison with Testo 350 Gas Analyzer for O_2 Validation

ICT utilizes a multi-probed Yokogawa O2-Mation device capable of delivering an in-situ wet O_2 reading and an ex-situ dry O_2 reading to a DCS. With no in leakage between the two points of measurement, once the wet-to-dry conversion is made the two readings are nearly identical, providing confidence in the O_2 concentration during all testing. In addition, the Yokogawa device is calibrated daily before testing begins.

ICT further validates the O_2 results by hooking an external analyzer (in this case, a Testo 350 gas analyzer) to a port located on the test chamber, to compare a third reading of O_2. Table 1 shows the comparison data from the DCS indicated reading to the Testo reading.

Table 1: Comparison of O_2 readings indicated by the DCS and the Testo analyzer

O2 Validation					
Time	15:46	15:47	15:48	15:49	15:50
DCS O_2	4.05	4.01	4.00	4.03	4.00
Testo O_2	3.99	3.98	4.02	3.98	3.95
Abs. Diff.	0.06	0.03	0.02	0.05	0.05
% Diff.	1.5%	0.8%	0.5%	1.2%	1.3%

Method 4 for H_2O Validation

ICT follows the EPA Method 4 to verify the accuracy of the FTIR readings for moisture content in the flue gas. Table 2 shows the comparison of an inlet FTIR, outlet FTIR, and the Method 4 results

Table 2: Comparison of FTIR measured values to the Method 4 indicated value

H2O Validation		
Start Time	9:39 AM	10:03 AM
End Time	9:49 AM	10:13 AM
Method 4	9.70	9.59
Inlet FTIR	10.17	9.98
% Diff, Method 4	4.88%	4.03%
Outlet FTIR	10.26	10.08
% Diff, Method 4	5.81%	5.07%
% Diff, Inlet and Outlet	0.88%	1.00%

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CTM-027 for NH_3 Validation

ICT follows the EPA Conditional Test Method 27 to verify the accuracy of the FTIR readings for NH_3 content in the flue gas. Table 3 shows the comparison of the FTIR to CTM-027.

Table 3: Comparison of FTIR measured values to the CTM-027 indicated value

CTM-027 NH_3 ppm	FTIR NH_3 ppm	Percent Difference	Absolute Difference
8.03	8.12	1.19%	0.10
4.68	4.54	2.97%	0.14

Velocity Traverse for Flow Validation

In order to validate the DCS indicated flow through the test chamber, a velocity traverse is conducted using a port location just after the test chamber. Table 4 shows the results of the traverse at a nominal 100 scfm setpoint.

Table 4: DCS indicated flow compared to calculated traverse flow at nominal 100 scfm

100 SCFM Setpoint			
Start Time	2:42 PM	2:44 PM	2:46 PM
End Time	2:44 PM	2:45 PM	2:46 PM
DCS Flow	98.4	99.8	102.1
Tested Flow	97.08	98.39	97.06
Error	1.36%	1.43%	5.19%
Avg Error	2.66%		

Repeatability Test – deNO_x, SO_2 Oxidation, and Differential Pressure

The ability to repeat the results of a test is an important part of any test facility. A sample that was tested previously was selected and retested for deNO_x activity, SO_2-SO_3 oxidation, and differential pressure. The results of this repeatability test are presented in Table 5.

Table 5: Activity, SO_2 oxidation, and differential pressure results during repeatability testing

Repeatability Test				
	Jan-21	Full Layer Est.	Jul-22	Full Layer Est.
Length, mm	700.5	1400	700.5	1400
Activity, k	35.1	35.1	33.4	33.4
SO_2-SO_3	0.515	1.030	0.531	1.061
dP	0.15	0.30	0.15	0.30

A small reduction in activity was observed (<5%) after a year and a half of the catalyst sample sitting in storage, with SO_2-SO_3 oxidation and differential pressure showing little to no difference in the results.

Repeatability Test - XRF

XRF is used to analyze the chemical composition of the catalyst as well as identify any uptake of poisons on or within the catalyst. A sample that was tested previously was selected and retested for XRF analysis. Table 6 contains the results of an XRF repeatability test.

Table 6: XRF repeatability test

Species	Units	Run 1	Run 2
TiO_2	wt%	64.64%	64.45%
WO_3	wt%	0.04%	0.03%
MoO_3	wt%	1.48%	1.51%
V_2O_5	wt%	2.37%	2.39%
SiO_2	wt%	5.19%	4.83%
Al_2O_3	wt%	2.30%	1.98%
CaO	wt%	1.04%	1.03%
MgO	wt%	BDL	BDL
Fe_2O_3	wt%	3.12%	2.86%
SO_3	wt%	5.21%	4.90%
K_2O	ppm	20.60	BDL
P_2O_5	wt%	1.46%	1.38%
Nb_2O_5	wt%	0.13%	0.13%
BaO	wt%	0.04%	0.03%
Cr_2O_3	wt%	2.02%	1.37%
As_2O_3	ppm	86.59	81.41
PbO	ppm	66.96	65.49

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FTIR Agreement for CO_2

Due to CO_2 remaining unreactive across SCR catalysts, an agreement between the inlet and outlet FTIR provides two reading for CO_2 in the flue gas. A comparison between the two FTIRs can be found in Table 7.

Table 7: Agreement between the inlet and outlet FTIR for CO_2

CO2 Agreement			
FTIR	Run 1	Run 2	Run 3
Inlet	8.05	8.07	8.09
Outlet	8.11	8.12	8.13
% Diff	0.74%	0.62%	0.49%